Cyanobacterial toxins in New York and the lower Great Lakes ecosystems

Boyer, Gregory L.[1]

1. State University of New York, College of Environmental Science and Forestry, Syracuse NY 13210

Introduction

The North American Great Lakes located between the United States and Canada collectively provide drinking water for >22 million people. In addition, numerous smaller lakes provide recreational opportunities for inhabitants and visitors to the northeastern US. Toxic cyanobacterial blooms were first reported in Lake Erie in the mid 1990's and are well documented in the relatively shallow western basin of Lake Erie where concentrations of microcystin LR (MC-LR) have exceeded 20 µg L^{-1}. Soon after, several dogs died along the shores of Lake Champlain after coming in contact with algal scums along the shoreline. NOAA, through their MERHAB and Sea Grant programs have supported extensive field studies to better understand the occurrence and distribution of these toxins in New York waters and the lower great lakes. These results of these five years of field studies are summarized here.

Methods

Samples for particulate toxin analysis between 1-20 liters were collected from more than 140 New York Lakes including Lakes Erie, Champlain and Ontario throughout the season (June – September) at a fixed depth (0.5-1 m) and the filters extracted using 50% acidified methanol. Microcystins were measured using a combination of assays including enzyme-linked immunoassay or ELISA, inhibition of the protein phosphatase 1A (PPIA) and by HPLC with PDA or MS detection. Anatoxin-a was determined by HPLC after derivatization with NBD-F and confirmed by LCMS. The PSP toxins (STX and neoSTX) were measured by HPLC with fluorescent detection after electrochemical oxidation. Cylindrospermopsin was measured by HPLC using PDA detection and confirmed by LCMS.

Results

More than 2500 samples were collected from lakes across New York State with an emphasis on Lakes Erie (n= 308), Lake Champlain (n=600) and Lake Ontario (n=736). In addition, several local lakes with well established toxic cyanobacterial blooms (Lake Oneida, n=317, Lake Agawam, n=136) were monitored heavily during this time period to examine the periodicity of toxicity. Microcystins were the most common cyanobacteria toxin found and occurred at concentration greater than 0.1 ug L in 38% of the samples tested. Approximately 15% of the samples from NY waters exceeded the WHOI advisory limit of 1 ug microcystin LR equivalents per liter. In contrast, 2300 samples were tested for anatoxin-a during the same time period. Of these, 190 (8%) contained detectable levels of anatoxin but only 16 samples (1%) contained anatoxin-a levels that exceeded 1 ug L-1. High concentrations of ATX were not observed in either Lake Erie or Lake Ontario, but concentrations exceeding 1 ug L-q were observed in Lake Champlain. Samples were also tested for cylindrospermopsin and the PSP toxins saxitoxin and neosaxitoxin. Detectable levels of cylindrospermopsin (0.01 ug L-1) were found in 8 of the 366 samples tested (2%). Detectable levels of PSP toxins (0.01 ug L-1) were found only twice during the five year period (n=1072). In all cases, the maximum concentration of these latter toxins were low (< 0.3 ug L-1).

Conclusions

Cyanobacteria blooms are common throughout New York state waters however historically, cyanobacteria toxins were not measured. In recent years, several widely publicized animal fatalities have occurred in New York waters due to cyanobacterial toxins. These include dog deaths in Lake Champlain in 1999 due to anatoxin-a and in 2000 due to microcystin toxicity, as well as a dog and water fowl deaths in Lake Neahtawanta in 2004. The presumptive toxin was identified based on the occurrence of toxins in the water, but the causative organisms was not identified and cultured. Several recreation closures due to cyanobacterial toxins have occurred throughout the region and toxic cyanobacterial blooms routinely occur near the water intakes for major drinking water facilities located along Lake Erie, Lake Ontario and Lake Champlain. To date, these toxins have not been observed in the water distribution system. These events have raised the awareness of cyanobacterial toxins in NY waters and as a result, several water treatment facilities and local health departments now sporadically monitor for cyanobacterial toxins.